

WHAT IS CLAIMED IS:

1 1. A process for producing an acetyl anhydride comprising contacting
2 methane and carbon dioxide in an anhydrous environment in the presence of effective
3 amounts of a transition metal catalyst and a reaction promoter, and an acid anhydride
4 compound, and optionally an acid, to produce a product comprising the acetyl anhydride.

1 2. A process according to claim 1 further comprising:

2 (b) contacting the product comprising the acetyl anhydride with water.

1 3. A process according to claim 2 further comprising recovering acetic
2 acid from step (b).

1 4. A process according to claim 1 further comprising:

2 (b) contacting the product comprising the acetyl anhydride with an alcohol.

1 5. A process according to claim 4 further comprising recovering an
2 acetate ester from the product of step (b).

1 6. A process according to claim 4 further comprising
2 recovering acetic acid from the product of step (b).

1 7. A process according to claim 1 in which the catalyst is a vanadium-
2 containing catalyst.

1 8. A process according to claim 7 in which the catalyst is selected from
2 vanadium pentoxide, vanadium trioxide, sodium metavanadate, vanadium-containing
3 heteropolyacid catalysts and vanadyl acetylacetonate.

1 9. A process according to claim 7 in which the catalyst is vanadyl
2 acetylacetonate.

1 10. A process according to claim 1 in which the reaction promoter is
2 selected from $K_2S_2O_8$, $K_4P_2O_8$, calcium dioxide, urea-hydrogen peroxide, and m-
3 chloroperbenzoic acid.

1 11. A process according to claim 10 in which the reaction promoter is
2 $K_2S_2O_8$.

1 12 A process according to claim 1 in which the acid anhydride compound
2 comprises sulfur trioxide, sulfur dioxide, trifluoroacetic acid anhydride,
3 fluoromethanesulfonic acid anhydride, trifluoromethanesulfonic acid anhydride,
4 fluorosulfonic acid anhydride, methanesulfonic acid anhydride, NO, NO₂, N₂O₅, P₂O₅, SeO₃,
5 As₂O₅, TeO₃, or B₂O₃ or a mixture of two or more of the foregoing.

6 13. A process according to claim 1 in which the acid anhydride compound
7 comprises trifluoroacetic acid anhydride.

1 14. A process according to claim 1 in which the acid anhydride compound
2 comprises trifluoromethanesulfonic acid anhydride.

1 15. A process according to claim 1 in which the acid anhydride compound
2 comprises sulfur trioxide.

3 16. A process according to claim 1 in which the acid anhydride compound
4 comprises fuming sulfuric acid.

1 17. A process according to claim 1 in which an acid is present during the
2 contacting.

1 18. A process according to claim 17 in which the acid comprises
2 trifluoroacetic, methanesulfonic, fluorosulfonic, fluoromethanesulfonic,
3 trifluoromethanesulfonic, sulfuric, fuming sulfuric, sulfurous, nitric, nitrous, phosphoric,
4 phosphorous, superphosphoric, or boric acid, or a selenium- and tellurium-containing analog
5 of the sulfur-containing acids, or a mixture of two or more of the foregoing.

1 19. A process according to claim 17 in which the acid comprises fuming
2 sulfuric acid.

1 20. A process according to claim 17 in which the acid comprises
2 trifluoroacetic acid.

- 1 21 A process according to claim 17 in which the acid comprises
2 trifluoromethanesulfonic acid.
- 1 22. A process according to claim 1 in which the acetyl anhydride
2 comprises acetyl sulfate.
- 1 23. A process according to claim 1 in which the acetyl anhydride
2 comprises acetyl trifluoroacetate.
- 1 24. A process according to claim 1 in which the acetyl anhydride
2 comprises acetyl trifluoromethanesulfonate.
- 1 25. A process according to claim 1 in which the temperature is from about
2 10 to about 200 °C.
- 1 26. A process according to claim 1 in which the temperature is from about
2 60 to about 100 °C.
- 1 27. A process for producing acetic acid comprising:
2 (a) contacting methane and carbon dioxide in an anhydrous environment in the
3 presence of effective amounts of a transition metal catalyst and a reaction promoter, and an
4 acid anhydride compound, and optionally an acid, to produce a product comprising an acetyl
5 anhydride; and
6 (b) contacting the product of step (a) with water.
- 1 28. A process according to claim 27, further comprising:
2 (c) recovering acetic acid from the product of step (b).
- 1 29. A process according to claim 27 in which the catalyst is a vanadium-
2 containing catalyst.
- 1 30. A process according to claim 29 in which the catalyst is selected from
2 vanadium pentoxide, vanadium trioxide, sodium metavanadate, vanadium-containing
3 heteropolyacid catalysts and vanadyl acetylacetonate.

- 1 31. A process according to claim 29 in which the catalyst is vanadyl
2 acetylacetonate.
- 1 32. A process according to claim 29 in which the reaction promoter is
2 selected from $K_2S_2O_8$, $K_4P_2O_8$, calcium dioxide, urea-hydrogen peroxide and m-
3 chloroperbenzoic acid.
- 1 33. A process according to claim 32 in which the reaction promoter is
2 $K_2S_2O_8$.
- 1 34. A process according to claim 27 in which the acid anhydride
2 compound comprises sulfur trioxide, sulfur dioxide, trifluoroacetic acid anhydride,
3 trifluoromethanesulfonic acid anhydride, fluoromethanesulfonic acid anhydride,
4 fluorosulfonic acid anhydride, methanesulfonic acid anhydride, NO, NO₂, N₂O₅, P₂O₅, SeO₃,
5 As₂O₅, TeO₃, or B₂O₃, or a mixture of two or more of the foregoing.
- 1 35. A process according to claim 27 in which the acid anhydride
2 compound comprises trifluoroacetic acid anhydride.
- 1 36. A process according to claim 27 in which the acid anhydride
2 compound comprises trifluoromethanesulfonic acid anhydride.
- 1 37. A process according to claim 27 in which the acid anhydride
2 compound comprises sulfur trioxide.
- 3 38. A process according to claim 27 in which the acid anhydride
4 compound comprises fuming sulfuric acid.
- 1 39. A process according to claim 27 in which an acid is present during the
2 contacting.
- 1 40. A process according to claim 39 in which the acid comprises
2 trifluoroacetic, fluorosulfonic, methanesulfonic, fluoromethanesulfonic,
3 trifluoromethanesulfonic, sulfuric, fuming sulfuric, sulfurous, nitric, nitrous, phosphoric,
4 phosphorous, superphosphoric or boric acid, or a selenium- or tellurium-containing analog of
5 the sulfur-containing acids, or a mixture of two or more of the foregoing.

1 41. A process according to claim 39 in which the acid comprises fuming
2 sulfuric acid.

1 42. A process according to claim 39 in which the acid comprises
2 trifluoroacetic acid.

1 43 A process according to claim 39 in which the acid comprises
2 trifluoromethanesulfonic acid.

1 44. A process according to claim 27 in which the acetyl anhydride
2 comprises acetyl sulfate.

1 45. A process according to claim 27 in which the acetyl anhydride
2 comprises acetyl trifluoroacetate.

1 46. A process according to claim 27 in which the acetyl anhydride
2 comprises acetyl trifluoromethanesulfonate.

1 47. A process according to claim 27 in which step (a) is conducted at a
2 temperature of from about 10 to about 200 °C.

1 48. A process according to claim 27 in which the step (a) is conducted at a
2 temperature of from about 60 to about 100 °C.

1 49. A process according to claim 27 further comprising recovering acetic
2 acid from step (b).

1 50. A process according to claim 39 in which an acid corresponding to the
2 acid used in step (a) is recovered from step (b), and said acid is recycled to step (a).

1
2 51. A process for the production of an acetate ester comprising:

3 (a) contacting methane and carbon dioxide in an anhydrous environment in the
4 presence of effective amounts of a transition metal catalyst and a reaction promoter, and an
5 acid anhydride compound, and optionally an acid, to produce a product comprising an acetyl
6 anhydride; and

7 (b) reacting the product of step (a) with an alcohol to produce a product comprising
8 an acetate ester.

1 52. A process according to claim 51, further comprising
2 (c) recovering the acetate ester from the product of step (b).

1 53. A process according to claim 51 in which the product of step (b)
2 further comprises acetic acid, said process further comprising:
3 (c) recovering acetic acid from the product of step (b).

4 54. A compound having the formula $\text{CH}_3\text{C}(\text{O})\text{-O-SO}_2\text{CF}_3$.